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Milkweed seed wing removal to improve oil extraction

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Abstract

Milkweed is now being grown commercially mainly for the production of floss used as hypoallergenic fillers in pillows and comforters. More recently, the use of milkweed seed oil in soaps and personal care products is being explored. The oil used in this effort was obtained by screw pressing whole milkweed seeds. The milkweed seed has a considerable amount of paper-thin wing around the edge of the hull. The light wing contributes greatly to the low bulk density of the seeds and the efficiency of oil extraction. This study explored the feasibility of removing the wings from the seeds to reduce the amount of material going into oil extraction. Hand-fractionation of the seeds showed that the wings, hulls, and kernel accounted for 12.2%, 51.2%, and 36.5% of the seed weight, respectively. The wing contained 1% of the total oil. Most of the oil is in the kernel (73%), but a significant amount is also found in the hulls (22.4%). Mechanical removal of seed wing was evaluated using an impact huller. Seeds (1 kg) with 4%, 7.2%, and 10% moisture were passed through the huller running at 1250 and 1750 rpm impeller speeds. The seeds discharged from the huller were screened to separate the intact seeds and partially dewinged seeds, dewinged seeds, and fines. Seed wings were effectively removed at seed moisture contents and impeller speed combinations of 7% and 1250 rpm or 10% and 1700 rpm. This was verified using 100 kg seeds. Removing the wings reduced the weight of the seeds by 13%, reduced the volume by 46%, and increased the bulk density by 63% while losing less than 5% of the total oil. The oil content of the dewinged seeds was 16.6% higher than the whole seeds. These reductions in seed weight and volume can significantly increase the output of the oil extraction equipment.

Keywords: Milkweed; *Asclepias syriaca*; *Asclepias speciosa*; Seed processing; Dehulling; Oil extraction

1. Introduction

Common milkweed (*Asclepias syriaca* L.) and showy milkweed (*Asclepias speciosa* Torr.) are now being grown commercially mainly for the production of floss fiber used as hypoallergenic fillers in comforters and pillows. The fresh pods, which contain 75% moisture, are dried to 10% moisture content in 48–60 h. The floss (Fig. 1) is separated from the seeds and pod hulls using cyclones and spike-toothed cylinders. Processing 10 units of pods produce 2 units of floss, 3 units of seeds, and 5 parts of pod hulls (Knudsen and Zeller, 1993; Von Bargen et al., 1994). The seeds are sold, to a limited extent, as planting material for highway beautification and prairie restoration projects. The seed meal may also be used to control Columbia root-knot nematode (*Meloidogyne chitwoodi*) on potatoes (Harry-O'kuru et al., 1999). More recently, the use of milkweed seed oil in personal care products is also being explored.

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[1] Names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of others that may also be suitable.

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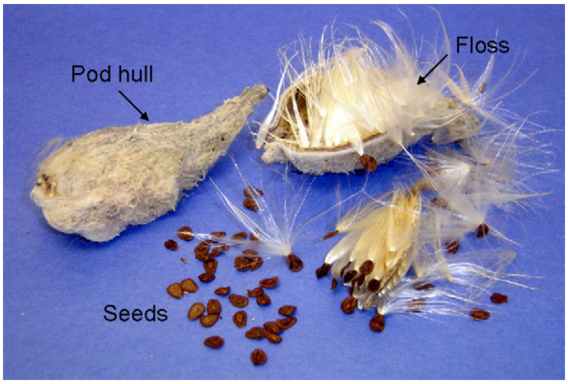

Fig. 1. Photograph of dried milkweed pod showing pod hull, floss, and seeds.

The oil used in this effort was obtained by cold pressing whole milkweed seeds.

Milkweed seed has a paper-thin extension (or "wing") around the edge of the hull (Fig. 2). This light wing has a large impact on the low bulk density and poor flow characteristics of milkweed seeds. Dehulling is usually performed before oil extraction to reduce the amount of material to be processed, thus increasing the throughput of the downstream processing equipment. It also reduces maintenance cost associated with the wear of the lining bars and shaft of the screw press. Furthermore, dehulling increases the protein content of the meal and reduces the wax that gets extracted with oil (Buhr, 1990; Williams and Hron, 1996). This study explored the feasibility of removing the wings from milkweed seeds to reduce the amount of material going into oil extraction. In this paper, a process of removing the seed wings is presented.

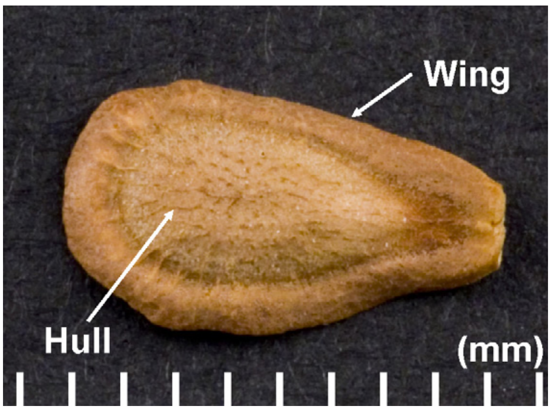

Fig. 2. Photograph of milkweed seed showing the wing around its side and the hull covering the kernel.

2. Materials and methods

2.1. Materials

Milkweed seeds used in this study were provided by the Natural Fiber Corporation (Ogallala, NE). The seeds were a mixture of common milkweed and showy milkweed seeds harvested from cultivated plots and natural stands.

2.2. Physical properties

Seed length, width at the widest side of the seed, and thickness were measured with a digital caliper from twenty intact seeds. Seed weight was obtained from the weight of three 1000 seed samples. Bulk density was determined by weighing three 2-l of seed samples, the volume of which were measured with a 2-l graduated cylinder.

2.3. Hand-fractionation of milkweed seeds

Wings were scraped off from 10 g of whole seeds. The dewinged seeds were spread on a paper towel moistened with distilled water and allowed to soak for at least 3 h to soften the hulls. Each seed was split at its pointed end with a razor blade. The hull was then peeled off and separated from the kernel. Weight, and oil and protein contents of each seed fraction were determined.

2.4. Mechanical dewinging of milkweed seeds

Seeds with 4%, 7.2% (as is), and 10% moisture contents (MC) were prepared. Seeds for 4% MC were obtained by drying the seeds at 60 °C in a vacuum oven until the target weight was attained. Seeds for 10% MC were prepared by spraying the seeds with a predetermined amount of distilled water. Seeds were allowed to equilibrate for at least 48 h. Seeds were then divided into 1-kg batches, placed in resealable polyethylene bags, and stored in an airtight 20-l pail.

The huller was a Forsberg Impact Huller Model 15-D (Forsbergs Inc., Thief River Falls, MN) (Fig. 3a). It had six boralloy steel impeller blades (6.4 cm wide × 24.8 cm long) mounted between two 30.5 cm diameter impeller plates (Fig. 3b). The impeller assembly was enclosed in a 0.6 cm thick boralloy steel impeller ring (69.5 cm in diameter × 7.6 cm high). The feed control was set to dispense 1 kg of seed per minute into the hulling chamber. Two impeller speed settings (1250 rpm and 1700 rpm) were employed. The 1250 rpm and 1700 rpm represent the minimum and maximum

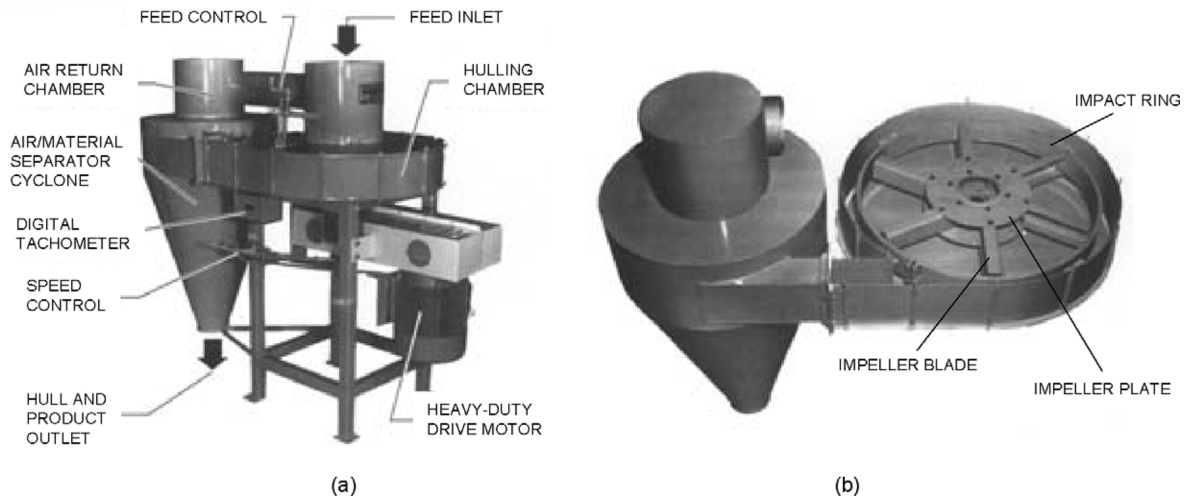

Fig. 3. Photographs of Forsberg impact huller model 15-D (a) and its exposed hulling chamber showing the assembly (b).

attainable impeller speeds of the huller. Three replicates were run for each moisture and huller speed combination. The material passing through the impact huller was screened for 15 min with a RO-TAP sieve shaker (Model RX 29, W.S. Tyler, Mentor, OH) and standard testing sieves (Table 1). Each screen fraction was weighed, placed in a resealable polyethylene bag, and then stored in an airtight 20-l pail.

After the suitable seed moisture and huller speed combination was determined, two 100-kg batches of seeds were processed as illustrated in Fig. 4. The seeds were fed into the huller at 1 kg/min with a variable speed flexible screw conveyor (Spiroflow Model FCS214B, Spriflow Systems, Inc., Monroe, NC). The material that passed through the huller was screened with a two-deck Rotex Model 12A screener (Rotex, Inc., Cincinnati, OH) fitted with a 6-mesh (3.53 mm opening) top screen and a 12-mesh (1.65 mm opening) bottom screen. The whole and partially dewinged seeds that were retained on top of the 6-mesh screen (+6 M) were sent back to the huller. The dewinged seeds went through the 6-mesh screen, but were retained on top of the 12-mesh screen (−6 M,+12 M). The light material in the dewinged seeds was aspirated with a Kice Model 6F6 Multiaspirator (Kice Industries, Inc.,Wichita, KS). The fines fraction (−12 M) and the light material aspirated from the dewinged seeds were set aside. Weights and bulk densities of the materials were determined after each step of the process. Samples were also taken for oil and moisture content determination.

Table 1
Sieve sizes used in RO-TAP screening of dewinged seeds

Sieve no.	Opening (mm)
8	2.36
10	2.00
12	1.70
14	1.40
18	1.00
25	0.71
(pan)	–

2.5. *Screw-pressing of dewinged seeds*

A single run of oil extraction by screw-pressing dewinged seeds was also performed. About 25 kg of

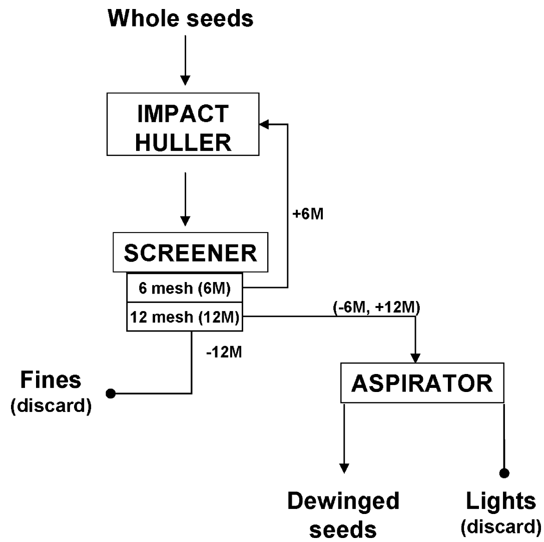

Fig. 4. Scheme for 100-kg batch milkweed seed wing removal. The streams +6 M, (−6 M, +12 M), and −12 M represent seed fractions bigger than 6 mesh, smaller than 6 mesh but larger than 12 mesh, and smaller than 12 mesh, respectively.

dewinged seeds were first heated to 82 °C in a three-deck seed conditioner/cooker (Laboratory Seed Conditioner Model 324, French Oil Mill Machinery Company, Piqua, OH). The total residence time in the conditioner was about 30 min and the seed's moisture content was reduced from 9.7 to 8.1%. The conditioned seeds were then pressed using a French Heavy-Duty Laboratory Screw Press (Model L-250) which had been preheated to 82 °C. The screw speed was at 22 rpm and the cone gap (distance between the bracket and cone mounting plate) at discharge was at 2.54 cm. A firm press cake was formed in less than 5 min. Two press cake samples were collected after the press was running at a steady state (as indicated by leveling off of the percent load reading on the control panel). Samples of starting seeds and press cakes were analyzed for moisture and oil contents.

2.6. Moisture, nitrogen, and oil content analyses

Moisture contents were determined gravimetrically as described in AOCS Ba 2-38 (AOCS, 1998). Nitrogen contents were determined by the combustion method on the LECO CHN 2000 (LECO Corporation, St. Joseph, MI) according to AOCS Ba 4e-93 (AOCS, 1998). Crude oil contents of hand-fractionated and whole seeds were determined by solvent extraction with the Foss Soxtec System HT 1043 Extraction unit (Foss Tecator Inc, Höganäs, Sweden) following AOCS Ba 3-38 (AOCS, 1998). Oil contents of all fractions processed through the huller were determined with the pulsed nuclear magnetic resonance (pNMR) spectrometer (Bruker PC120, Bruker Optik GmbH, Rheinstetten, Germany) following AOCS Ak 4-95 (AOCS, 1998). All analyses were performed in duplicate.

2.7. Statistical analysis

Statistical analyses were performed using PROC MIXED in SAS Version 9.1 for PC (SAS Institute, Inc., Cary, NC). Differences in least square mean estimates of moisture content and impeller speed with a Bonferroni adjustment were examined to determine significant differences ($P \leq 0.05$) in weight and oil content of fractions from each moisture and impeller speed combination.

3. Results and discussion

The seeds used in this study were a mixture of common and showy milkweeds seeds. The physical properties and partial proximate composition of the seeds are shown in Table 2. The weight of a thousand seeds (5.4 g, db) was less than the previously reported value (7.2 g, db) for *A. speciosa* seeds (New Crops Database, 1999). Oil and crude protein contents of the seed samples were both in the lower range of literature values, which were 21 to 32% (db) for oil and 32 to 37% (db) for protein (New Crops Database, 1999).

Table 2
Physical properties and oil, protein, and moisture contents of milkweed seed

Length (mm)	7.45 ± 0.56
Width (mm)	4.65 ± 0.46
Thickness (mm)	0.73 ± 0.10
Seed weight (g/1000)	5.88 ± 0.01
Bulk density (g/L)	182.2 ± 2.8
Oil (%)	19.0 ± 0.7
Crude protein (%)	29.5 ± 0.2
Moisture (%)	7.2 ± 0.2

Values represent mean ± standard deviation.

Hand-fractionation of the seeds to separate the wings, hulls and kernel was performed to establish the baseline for wing removal and dehulling of the milkweed seeds. The wings accounted for 12.2% of the seed weight, and contained 1% of the total oil and 4% of the total protein in the seed (Table 3). The hulls made up about one-half of the dry seed weight and 22.5% of the total oil in the seed. Hulls protein content was nearly the same as that of the whole seed. The small kernel was 36.5% of the seed weight, but contained 73% of the total oil in the seed. By doing a mass balance, complete removal of the 12.2% wings will result in dewinged seed with an oil content of about 22.4% (db). Although the weight of the whole seed can be reduced further to 63% by removing both wings and hulls, at least 24% of the total oil will also be lost in the process. Unless there is a need for high-protein, defatted kernels (up to 66% protein, db), complete dehulling of the seed is not desirable.

The wings are easily broken off from the seed. It was anticipated that an impact huller would be appropriate for this purpose. However, a suitable seed moisture and huller impeller speed combination must be established to minimize oil loss. The typical MC of seeds for full

Table 3
Weight distribution and oil and protein contents of milkweed seed fractions

	Weight (%, db)	Oil[a] (%, db)	Crude protein[a,b] (%, db)
Whole seed	100.0	20.5 ± 0.2	31.8 ± 0.1
Kernel	36.5	41.1 ± 0.0	39.3 ± 0.6
Wings	12.2	1.9 ± 0.4	10.1 ± 0.2
Hulls	51.2	9.0 ± 0.4	30.9 ± 0.1

[a] Values represent mean ± standard deviation.
[b] Crude protein = %N × 6.25.

Table 4
Weight distribution and oil contents of milkweed seeds fractions from 1-kg seeds after one pass through the impact huller

Fraction number	Seed moisture (%)	Huller speed			
		1250 rpm		1700 rpm	
		Fraction weight[a] (%)	Oil content[a] (%, db)	Fraction weight[a] (%)	Oil content[a] (%, db)
8	4.0	17.7 ± 0.6 C	22.6 ± 0.4 a	4.1 ± 0.7 D	22.1 ± 0.5 a
	7.2	43.1 ± 0.6 B	23.3 ± 0.4 a	16.4 ± 0.6 C	22.7 ± 0.4 a
	10.0	66.8 ± 0.6 A	23.7 ± 0.4 a	42.1 ± 0.6 B	22.7 ± 0.4 a
10	4.0	33.7 ± 0.3 AB	25.4 ± 0.3 a	20.0 ± 0.4 D	24.3 ± 0.3 a
	7.2	31.1 ± 0.3 BC	25.4 ± 0.3 a	34.8 ± 0.3 A	25.4 ± 0.3 a
	10.0	18.9 ± 0.3 D	24.7 ± 0.3 a	30.3 ± 0.3 C	25.4 ± 0.3 a
12	4.0	24.2 ± 0.4 A	25.0 ± 0.2 ab	24.7 ± 0.4 A	25.0 ± 0.2 ab
	7.2	12.9 ± 0.4 C	24.7 ± 0.2 ab	21.3 ± 0.4 B	25.2 ± 0.2 a
	10.0	6.1 ± 0.4 D	24.1 ± 0.2 b	13.6 ± 0.4 C	25.2 ± 0.2 a
14	4.0	6.0 ± 0.1 B	22.1 ± 0.4 a	11.2 ± 0.1 A	23.3 ± 0.4 a
	7.2	2.0 ± 0.1 C	19.2 ± 0.4 b	6.0 ± 0.1 B	21.9 ± 0.4 a
	10.0	0.9 ± 0.1 D	17.3 ± 0.4 c	2.3 ± 0.1 C	21.9 ± 0.4 a
18	4.0	4.7 ± 0.0 C	17.5 ± 0.4 ab	10.7 ± 0.0	20.2 ± 0.5 a
	7.2	2.4 ± 0.0 E	10.6 ± 0.4 c	5.7 ± 0.0 B	15.6 ± 0.4 b
	10.0	1.6 ± 0.0 F	8.6 ± 0.4 c	2.7 ± 0.0 D	15.6 ± 0.4 b
25	4.0	5.5 ± 0.0 C	10.9 ± 1.4 b	11.6 ± 0.0 A	16.7 ± 1.6 a
	7.2	3.4 ± 0.0 E	6.9 ± 1.4 c	6.0 ± 0.0 B	12.9 ± 1.4 b
	10.0	2.4 ± 0.0 F	6.3 ± 1.4 c	3.7 ± 0.0 D	12.9 ± 1.4 b
Pan	4.0	8.2 ± 0.2 B	10.3 ± 0.6 b	17.9 ± 0.2 A	15.4 ± 0.6 a
	7.2	5.1 ± 0.2 C	5.8 ± 0.6 c	9.8 ± 0.2 B	10.3 ± 0.6 b
	10.0	3.4 ± 0.2 D	4.9 ± 0.6 c	5.4 ± 0.2 C	10.3 ± 0.6 b

[a] Values represent mean ± standard error of three determinations. Means within each fraction (uppercase letters for fraction weight and lowercase letters for oil content) followed by different letter superscript are significantly different ($P \leq 0.05$).

pressing is about 3–4%, whereas 10% is the MC at which pods are usually processed for separation of the floss. The seeds used in this study had a moisture content of 7.2% as received.

Visual inspection of the screened through material from the huller showed that the whole or partially dewinged seeds and some large dewinged seeds were retained in fraction No. 8. This fraction will be referred to as the recycle fraction. Whole or large broken pieces of dewinged seeds were retained in fraction Nos. 10 and 12. Fraction No. 14 contained smaller broken pieces of dewinged seeds and some kernels. The dewinged seed fraction was composed of fraction numbers 10, 12, and 14. The fines fractions (Nos. 18, 25 and pan) contained wings and hulls in varying proportions.

In general, moisture and huller speed had significant effects on the weights of the fractions, and on the oil contents of only the fines fraction (Table 4). The amount of recycle fraction increased with increasing moisture and decreased with increasing huller speed. The amount of fines increased with decreasing seed moisture and increasing huller speed. All recycle fractions had oil contents slightly higher than that of the whole seeds (Tables 2 and 4). This is due to the presence of partially dewinged seeds, large dewinged seeds and large seeds with broken edges. All fractions 10 and 12 also had oil contents higher than what was expected for completely dewinged seeds. This is largely due to the seeds with some hulls broken off, but still contained intact kernels (Fig. 5). Although fractions 14 were mostly smaller broken seed pieces, they also had some kernels (completely dehulled seeds) that contributed to their high oil contents. Oil contents of several fines fractions were more than 9%, indicating that, aside from wings and hulls, these fractions also contained small amounts of kernels.

The seeds with 4% moisture and processed at 1250 rpm huller impeller speed had the least amount of recycle fraction and the most amount of dewinged seed fractions (Table 4). Increasing the impeller speed to 1700 rpm reduced the recycle fraction by 76% and increased the amounts of fine fractions by 118%. More kernels also ended up with the fines fractions as manifested by the 15% to 53% increase in oil contents.

Fig. 5. Photographs of the manually-dewinged milkweed seeds (a) and milkweed seeds dewinged with an impact huller (b).

Seeds with 7.2% MC and processed at 1250 rpm had 144% more recycle fraction than the seeds with 4% MC processed at the same speed. As a result, the amounts of dewinged seed and fines fractions were lower by 28% and 41%, respectively (Table 4). However, the oil contents of the fines fractions were much lower, ranging between 6 and 11%. The recycle fraction decreased by 62% and the dewinged seed fractions increased to 35% when the impeller speed was increased to 1700 rpm. The amount of fines fraction doubled and oil content also increased by 66%.

Seeds with 10% MC and processed at 1250 rpm had the largest amount of recycle fraction and the smallest amounts of dewinged seed fractions and fines fractions (Table 4). The oil contents of the fines fractions were the same as that of the fines from 7.2% seeds. Increasing the speed to 1700 rpm decreased the recycle fraction by 37% and increased the dewinged seed fraction by 78%. The amount of fines fraction and oil content increased by 60% and 96%, respectively.

To get an estimate of the amounts of fine fractions that can be discarded and how much oil will be lost, the recycle fractions in Table 4 were excluded and the fraction and oil distribution were recalculated (Table 5). The 4% MC level was evidently too low for dewinging milkweed seeds. Approximately 13% of the total oil was already lost to the fines fraction even at the lowest impeller speed. Also, seeds with 7.2% MC could not withstand the 1700 rpm impeller speed. Nearly 26% fines fraction was generated, which contained almost 15% of the total oil. Three seed moisture and huller speed combinations (7.2%-1250 rpm, 10%-1250 rpm, and 10%-1700 rpm) produced the least oil losses in the fines. Because the seeds with 10% moisture and processed at 1250 rpm had the highest recycle fraction (Table 4), the 7.2%-1250 rpm and 10%-1700 rpm combinations were considered suitable moisture and huller speed conditions for removing milkweed seed wings. Seed moisture content of about 7% is the minimum for dewinging at 1250 rpm.

Table 5
Weight and oil distribution of huller through material for 1-kg seeds excluding recycle fraction (from Table 4)

Fraction	Seed moisture (%)	Huller speed			
		1250 rpm		1700 rpm	
		Fraction distribution[a] (%)	Oil distribution[a] (%)	Fraction distribution[a] (%)	Oil distribution[a] (%)
Dewinged seeds	4.0	77.7 ± 0.3 B	87.4 ± 0.4 b	58.3 ± 0.3 D	65.3 ± 0.4 c
	7.2	80.9 ± 0.3 A	93.6 ± 0.4 a	74.3 ± 0.3 C	85.3 ± 0.4 b
	10.0	78.0 ± 0.3 B	93.3 ± 0.4 a	79.7 ± 0.3 A	93.8 ± 0.4 a
Fines	4.0	22.3 ± 0.3 C	12.6 ± 0.5 b	41.7 ± 0.3 A	34.7 ± 0.5 a
	7.2	19.1 ± 0.3 D	6.4 ± 0.5 c	25.7 ± 0.3 B	14.7 ± 0.5 b
	10.0	22.0 ± 0.3 C	6.7 ± 0.5 c	20.4 ± 0.3 D	6.2 ± 0.5 c

[a] Values represent mean ± standard error of three determinations. Means within each fraction (uppercase letters for fraction distribution and lowercase letters for oil distribution) followed by different letter superscript are significantly different ($P \leq 0.05$).

Table 6
Weight distribution, bulk density, and oil content of 100-kg batch dewinged milkweed stream

	Weight[a] (%)	Bulk density[a] (g/L, dry)	Oil content[a] (%, db)	Oil distribution (%)
Dewinged seeds				
First pass	62.7 ± 1.3	276 ± 0.3	24.2 ± 0.8	70.8
Second pass	19.4 ± 1.1	283 ± 4.2	23.7 ± 0.2	21.5
Third pass	5.6 ± 1.4	264 ± 24.8	21.1 ± 0.4	5.5
Total	87.7 ± 1.2	276 ± 0.9	23.9 ± 0.6	97.8
For discard				
−12 M fines	9.1 ± 0.6	109 ± 4.0	6.9 ± 0.2	2.9
Third pass, +6 M	3.5 ± 0.7	142 ± 0.7	9.8 ± 3.8	1.6
Aspirator lights	0.6 ± 0.1	68 ± 1.5	7.7 ± 0.6	0.2
Total	13.2 ± 0.1	–	7.8 ± 1.3	4.7

[a] Values represent mean ± standard deviation of two determinations.

To verify the results from the 1-kg batch, 100-kg batches of whole seeds were dewinged. Although the seed moisture during the time of processing had increased to 8.5%, it was decided that the lower impeller speed setting still be used. The preliminary runs using 8-mesh sieve in the continuous screener retained significant amounts of dewinged seeds. This could be due to the short residence time of the material in the screener. The top screen was then changed to 6-mesh, which gave better separation. A 12-mesh screen was also used to make the bottom cut for the dewinged seeds. Although the No. 14 fraction had more than 10% oil content, the amount was still low enough so that oil loss was actually minimal. The +6 M fraction was sent back to the huller until the seeds were dewinged (Fig. 4).

The recycle fraction after the first pass through the huller was 37% (Table 6). This is 6% lower than that obtained from 7.2% MC seeds processed at 1250 rpm in the 1-kg batch. This could be due to the different screen size used. After the third pass through the huller, the +6 M material was reduced to mostly pod hulls (present in the starting material) and the oil content was about 10%. About 88% of the total material was dewinged seeds, of which 71% was obtained from the first pass. The oil content of the dewinged seed was 24%, which was 17% higher than that of the starting whole seed. The dewinged seed had an average density of 276 g/L, 63% higher than that of the whole seeds. The discard fraction amounted to 13% and the oil content of the combined material was 7.8%. The discard fraction contained less than 5% of the total oil. The amount of light materials removed by the aspirator from the dewinged seeds was 0.6% and contained only 0.2% of the total oil. This indicated that the aspiration step may be unnecessary.

The dewinged seed going into the screw press had an oil content of 23.4% (db). The 22 rpm screw speed used in this run is at the lower end of the 20–30 rpm range suggested by the equipment manufacturer for full pressing. The press cake had a residual oil content of 14.0% (db), indicating an oil recovery of 46.7%. Holser (2003) reported a 12.1% yield (calculated from weight of filtered crude oil and the weight of the seeds) from screw pressing whole milkweed seeds (containing 23% oil, db) using a pilot-scale expeller. With this yield, it was estimated that the press cake would have a 12.4% (db) residual oil. The oil recovery can be still improved by optimizing seed preparation (which includes flaking the seeds, cooking, and drying the seeds to optimum moisture for pressing) and expeller settings.

In the commercial full-press extraction of oilseeds, the residual oil in the press cake varied from 3 to 10% (Williams and Hron, 1996; O'Brien, 2004). These residual oil contents are 1.6 to 5.3 times higher than the initial oil content of the wings. If the whole seed has an oil content of 20.5% (db), about 0.6–5.3% of the total oil would be absorbed by the wings during pressing. More oil will be lost (absorbed by the wings) by pressing whole seeds when the residual oil in the press cake is greater than 10%, compared to what will be lost in discarded fines by removing the wings.

4. Conclusions

Removal of milkweed seed wings can be effectively achieved by using an impact- type huller. Seeds should have a minimum moisture content of about 7% and must be processed at low huller impeller speeds to minimize the loss of oil in the fines. Seeds with higher moisture contents can withstand faster impeller speeds, and thus, must be adjusted accordingly. The suitable seed moisture content and impeller speed combinations were 7%-1250 rpm and 10%-1700 rpm. Removing the wings reduced the seed weight by 13% while losing less than 5% of the total oil. The dewinged seeds have 16.6% more oil than the whole seeds. Removing the light wings decreased the volume by 46%, resulting in a 63% increase in the bulk density. The large decrease in the volume of seeds can lead to a large increase in the throughput of the oil extraction equipment.

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